

III. SKELETAL SYSTEM

THE BONY THORAX

24

See 22

CN: Use the same colors as were used on Plate 22 for true ribs, thoracic vertebrae, demifacets, and transverse process facets. Use bright colors for A-C. (1) Color the anterior view of the bony thorax. Color each rib completely before going on to the next. (2) Color the posterior

view in the same manner. (3) Color the lateral view of the bony thorax. (4) When coloring the drawings of a rib and the sites of articulation, note that the rib facets (drawn with dotted lines) are to be colored even though they are on the underside of the rib.

STERNUM:

MANUBRIUM^A

BODY^B

XIPHOID PROCESS.

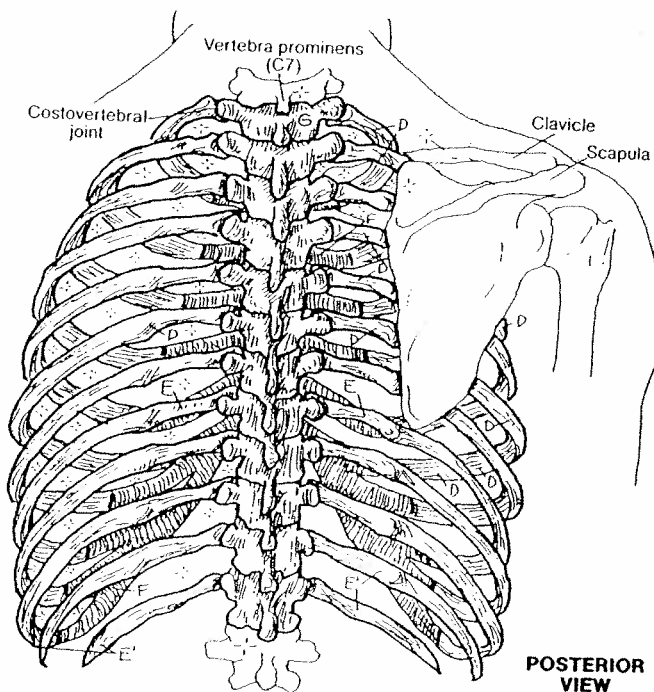
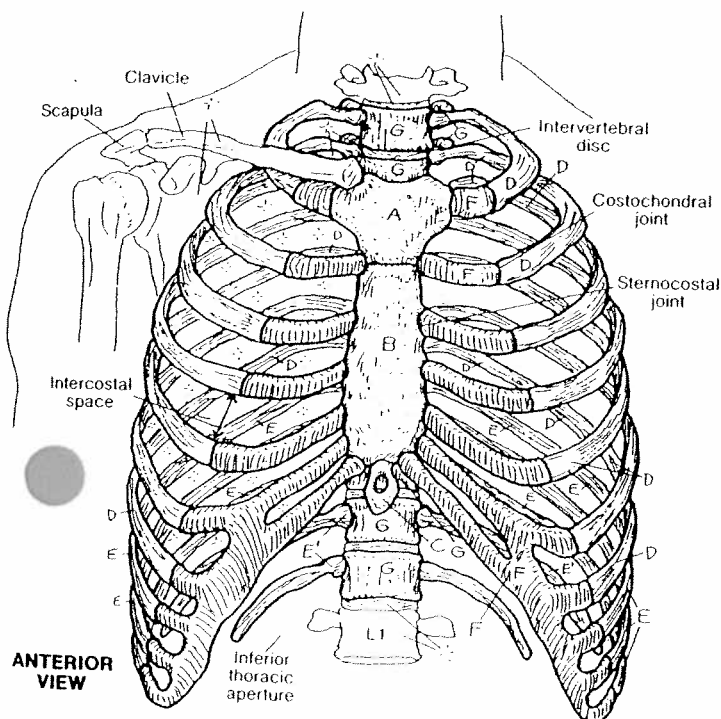
12 RIBS:

7 TRUE^D

5 FALSE^E

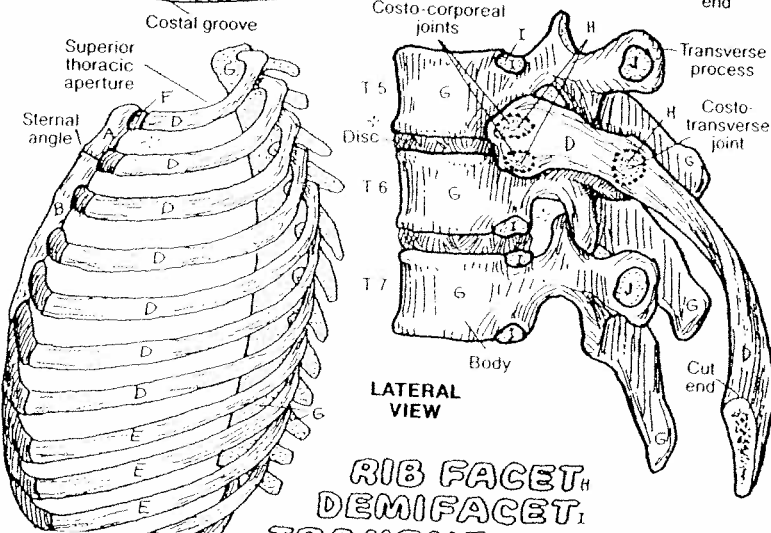
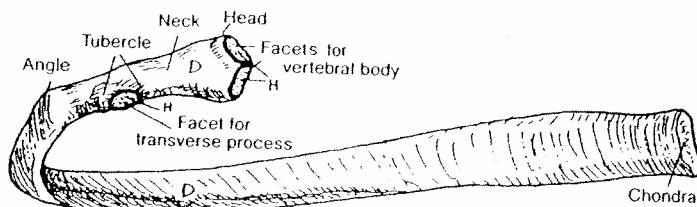
(2 FLOATING)^{E'}

COSTAL
CARTILAGE (10)^F
THORACIC
VERTEBRA (12)^G



The bony thorax is the skeleton of the chest, representing a fairly mobile set of structures important to respiration and harboring the heart, lungs, and other significant organs. The superior thoracic aperture (thoracic inlet; often incorrectly termed thoracic outlet in a clinical context) transmits the esophagus, trachea, nerves, and important ducts and vessels. The inferior thoracic aperture is virtually sealed by the thoracic diaphragm. The space between ribs is the intercostal space, and contains three layers of muscle and fascia, and intercostal vessels and nerves. Collective rib movement is responsible for about 25% of the respiratory effort.

The fibrocartilaginous joint between the manubrium and the body of the sternum (sternal angle, sternomanubrial joint) makes subtle hinge-like movements during respiration. The xiphoid makes a fibrocartilaginous (xiphisternal) joint with the body of the sternum. The sternum is largely cancellous bone containing red marrow. The costal cartilages, representing unossified cartilage models of the anterior ribs, articulate with the sternum by gliding type synovial joints (sternocostal joints; except for the first joint, which is not synovial). All ribs form synovial joints with the thoracic vertebrae (costovertebral joints). Within each of these joints, the rib (2 through 10) forms a synovial joint with a demifacet of the upper vertebral body and with a demifacet of the lower body (costocorporeal joint). In addition, the tubercle of the rib articulates with a cartilaginous facet at the tip of the transverse process of the lower vertebra (costotransverse joint). Ribs 1, 10, 11, 12 each join with one vertebra instead of two; ribs 11 and 12 have no costotransverse joints. True ribs (1-7) articulate directly with the sternum; false ribs (8-12) articulate indirectly with the sternum (via cartilages connecting to the 7th costal cartilage; floating ribs (11, 12) end in the



III. SKELETAL SYSTEM

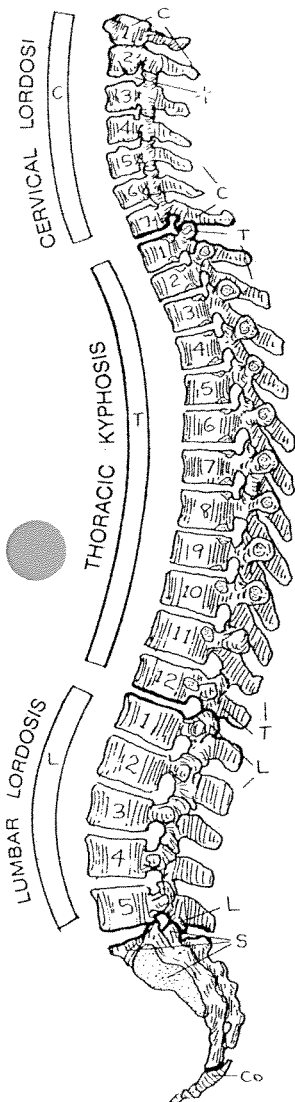
VERTEBRAL COLUMN

CN: Use gray for D, yellow for H, and light colors for the rest, especially C, T, L, S, and Co. (1) Begin with regions of the column and the three examples of vertebral disorders at lower left. (2) Color the motion segment and its role in flexion and extension. (3) Color the vertebral foramina and canal. (4) Color the example of a protruding intervertebral disc pressing on a spinal nerve.

21

See 22, 23

REGIONS:
CERVICAL_C
THORACIC_T
LUMBAR_L
SACRAL_S
COCCYGEAL_{Co}



The vertebral column has 24 individual vertebrae arranged in cervical, thoracic, and lumbar regions; the sacral and coccygeal vertebrae are fused (sacrum/coccyx). Numbers of vertebrae in each region are remarkably constant; rarely S1 may be free or L5 may be fused to the sacrum (transitional vertebrae). The seven mobile cervical vertebrae support the neck and the 3-4 kg (6-8 lb) head. The cervical spine is normally curved (*cervical lordosis*) secondary to the development of postural reflexes about three months after birth. The 12 thoracic vertebrae support the thorax, head, and neck. They articulate with 12 ribs bilaterally. The thoracic spine is congenitally curved (*kyphosis*) as shown. The five lumbar vertebrae support the upper body,

torso, and low back. The column of these vertebrae is curved (*lumbar lordosis*) due to the onset of walking at 1-2 years of age. The sacrum is the keystone of a weightbearing arch involving the hip bones. The sacral/coccygeal curve is congenital. The variably numbered 1-5 coccygeal vertebrae are usually fused, although the first vertebra may be movable.

Vertebral curvatures may be affected (usually exaggerated) by posture, activity, obesity, pregnancy, trauma, and/or disease; these conditions are named the same as the normal curves. There may normally be a slight lateral curvature to the spine often due to dominant handedness; a significant, possibly disabling, lateral curve (*scoliosis*) may occur for many reasons.

MOTION SEGMENT:_{*}

VERTEBRA_L

JOINTS:₊

INTERVERTEBRAL DISC_A
POSTERIOR (FACET)_B

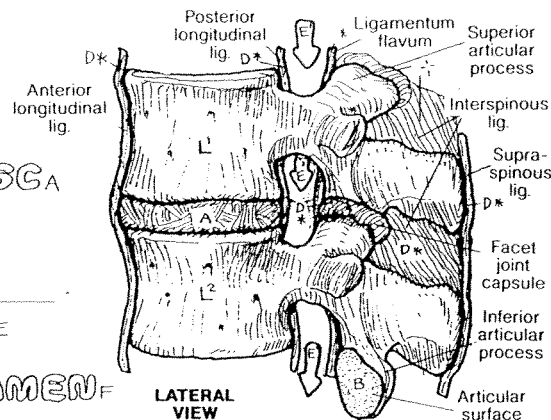
LIGAMENT_{D*}
VERTEBRA_{L²}

VERTEBRAL FORAMEN_E

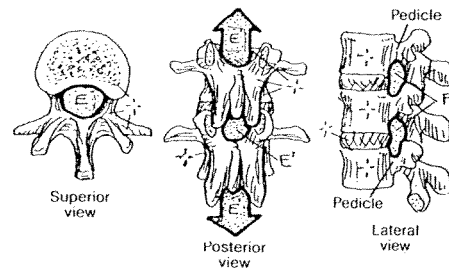
VERTEBRAL CANAL_{E'}

INTERVERTEBRAL FORAMEN_F

Each pair of individual, unfused vertebrae constitutes a *motion segment*, the basic movable unit of the back. Combined movements of motion segments underlie movement of the neck, middle and low back. Each pair of vertebrae in a motion segment, except C1-C2, is attached by three joints: a partly movable, *intervertebral disc* anteriorly, and a pair of gliding synovial *facet (zygapophyseal) joints* posteriorly. *Ligaments* secure the bones together and encapsulate the facet joints (joint capsules). The *vertebral* or *neural canal*, a series of *vertebral foramina*, transmits the spinal cord and related coverings, vessels, and nerve roots. Located bilaterally between each pair of vertebral pedicles are passageways, each called an *intervertebral foramen*, transmitting spinal nerves, their coverings/vessels, and some vessels to the spinal cord.



LATERAL VIEW



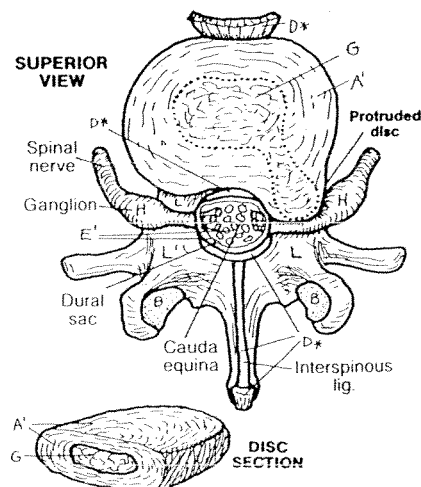
INTERVERTEBRAL DISC_A

ANNULUS FIBROSUS_{A'}

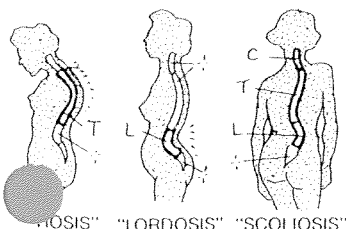
NUCLEUS PULPOSUS_G

SPINAL NERVE_H

The intervertebral disc consists of the *annulus fibrosus* (concentric, interwoven collagenous fibers integrated with cartilage cells) attached to the vertebral bodies above and below, and the more central *nucleus pulposus* (a mass of degenerated collagen, proteoglycans, and water). The discs make possible movement between vertebral bodies. With aging, the discs dehydrate and thin, resulting in a loss of height. The cervical and lumbar discs, particularly, are subject to early degeneration from one or more of a number of causes. Weakening and/or tearing of the annulus can result in a broad-based bulge or a localized (focal) protrusion of the nucleus and adjacent annulus; such an event can compress a spinal nerve root as shown



VERTEBRAL DISORDERS



KYPHOSIS "LORDOSIS" "SCOLIOSIS"

III. SKELETAL SYSTEM:

CERVICAL AND THORACIC VERTEBRAE

22

See 21, 23

CN: Use red for M and use the same colors as were used on Plate 21
and T. Use dark colors for N, O, and P. (1) Begin with the parts of
cervical vertebra. Color the atlas and axis and note they have been
separate colors to distinguish them from other cervical vertebrae.
(2) Color the parts of a thoracic vertebra and then the thoracic portion
of the vertebral column. Note the three different facet/demifacet colors.

CERVICAL VERTEBRA

BODY_C

PEDICLE_C

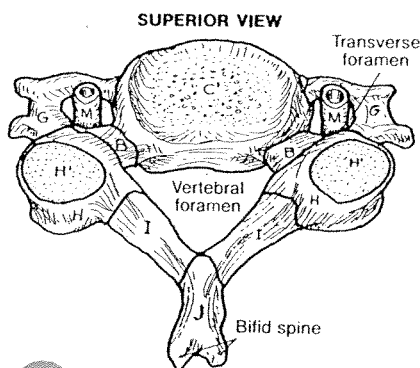
TRANSVERSE PROCESS_C

ARTICULAR PROCESS_H

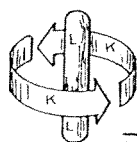
FACET_H

LAMINA_I

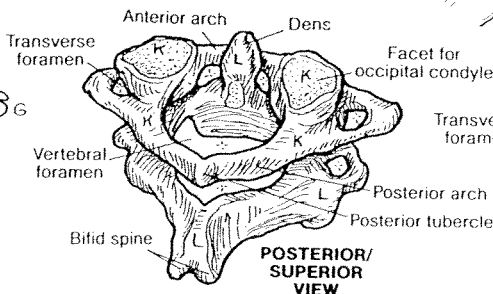
SPINOUS PROCESS_I



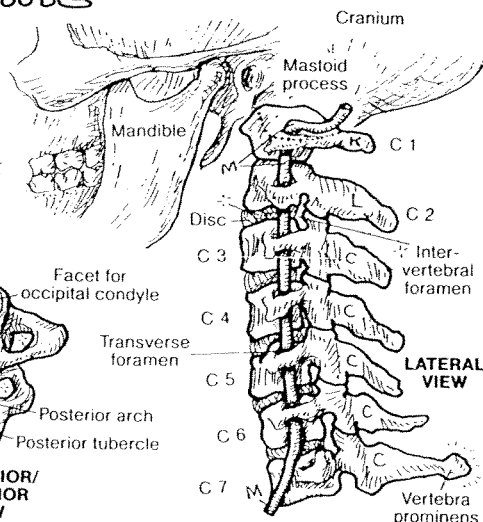
TYPICAL CERVICAL (C4) VERTEBRA



ATLAS_K
AXIS_L

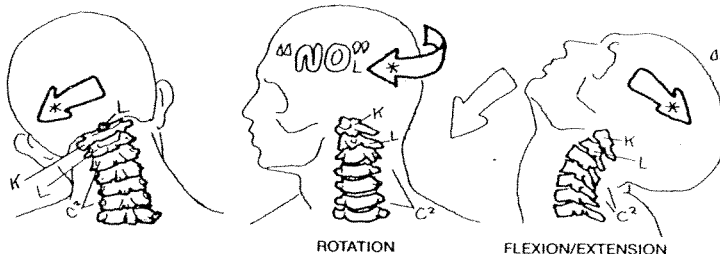


POSTERIOR/
SUPERIOR
VIEW



LATERAL VIEW

MOVEMENT*



ROTATION

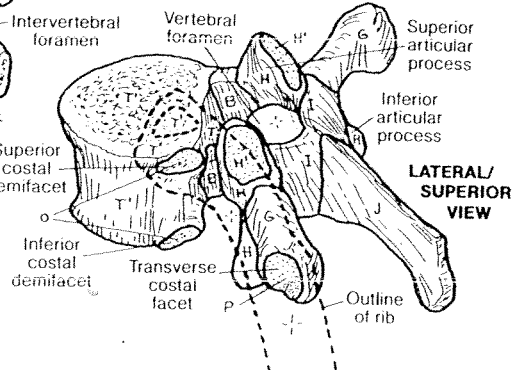
FLEXION/EXTENSION

VERTEBRAL ARTERY_M

The small seven *cervical vertebrae* support and move the head and neck, supported by ligaments and strap-like paracervical (paraspinal) muscles. The ring-shaped *atlas* (C1) has no body; thus there are no weight-bearing discs between the occiput and C1, and between C1 and C2 (the axis). Head weight is transferred to C3 by the large *articular processes* and *facets* of C1 and C2. The atlantooccipital joints, in conjunction with the C3-C7 facet joints, permit a remarkable degree of flexion/extension ("yes" movements). The dens of C2 projects into the anterior part of the C1 ring, forming a pivot joint, enabling the head and C1 to rotate almost 90° ("no" movements). Such rotational capacity is permitted by the relatively horizontal orientation of the cervical facets. The C3-C6 vertebrae are similar; C7 is remarkable for its prominent *spinous process*, easily palpated. The anteriorly directed cervical curve and the extensive paracervical musculature preclude palpation of the other cervical spinous processes. The *vertebral arteries*, enroute to the brain stem, pass through foramina of the *transverse processes* of the upper six cervical vertebrae. These vessels are subject to stretching injuries with extreme cervical rotation of the hyperextended neck. The cervical vertebral canal conducts the cervical spinal cord and its coverings (not shown). The C4-5 and C5-6 motion segments are the most mobile of the cervical region and are particularly prone to disc/facet degeneration.

The twelve *thoracic vertebrae*—characterized by long, slender spinous processes, heart-shaped *bodies*, and nearly vertically oriented *facets*—articulate with *ribs* bilaterally. In general, each rib forms a synovial joint with two *demifacets* on the bodies of adjacent vertebrae and a single *facet* on the transverse process of the lower vertebra. Variations of these costovertebral joints are seen with T1, T11, and T12.

TYPICAL THORACIC (T5) VERTEBRA



LATERAL/
SUPERIOR
VIEW

THORACIC VERTEBRA_T

BODY_T

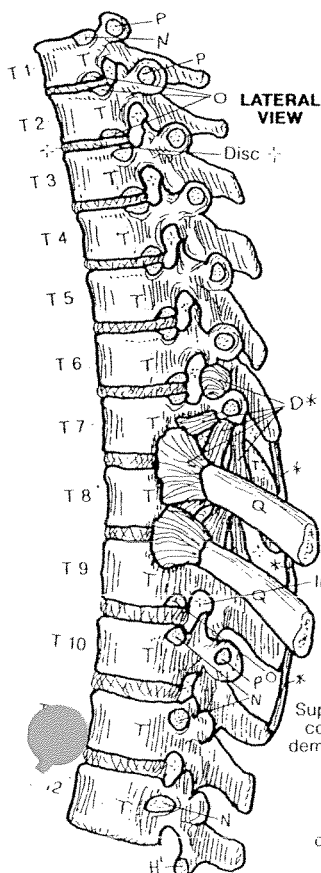
FACET_N

DEMIFACET_I

TRANSVERSE FACET_P

RIB_Q

LIGAMENT_{D*}



LATERAL VIEW

III. SKELETAL SYSTEM

LUMBAR, SACRAL, & COCCYGEAL VERTEBRAE

23

See 21, 22

CN: Use the same colors as were used on the previous two plates for E, F, A, S, and Co. (1) Begin with the three large views of lumbar vertebrae. (2) Color the different planes of articular facets. (3) Color views of the sacrum and coccyx. Note that the central portion of the median section receives the vertebral canal color (E').

LUMBAR VERTEBRA

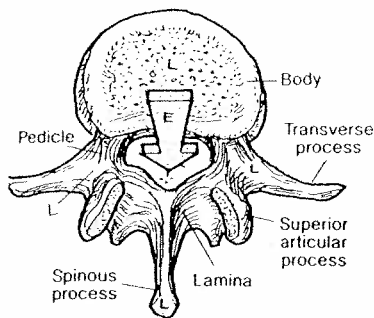
VERTEBRAL FORAMEN_E

VERTEBRAL CANAL_{E'}

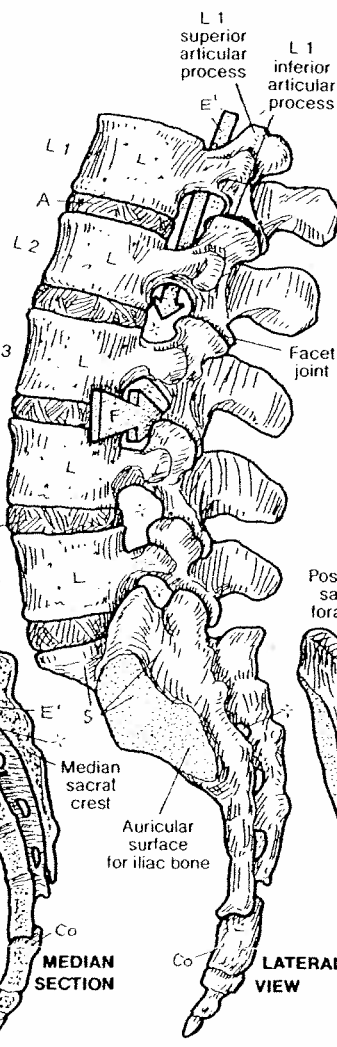
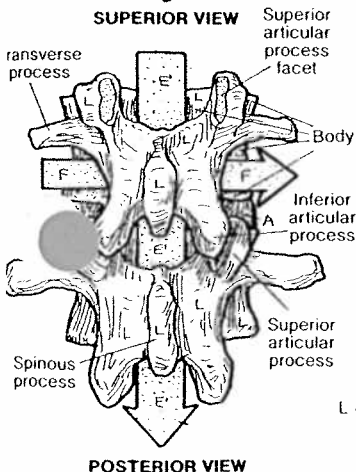
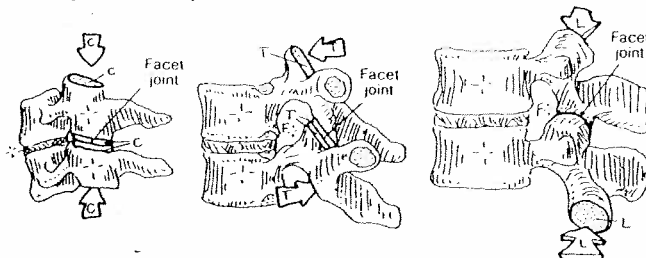
INTERVERTEBRAL FORAMEN_F

INTERVERTEBRAL DISC_A

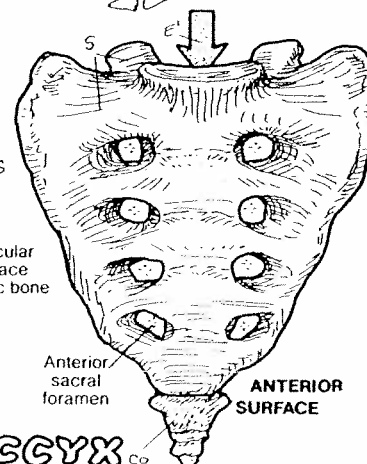
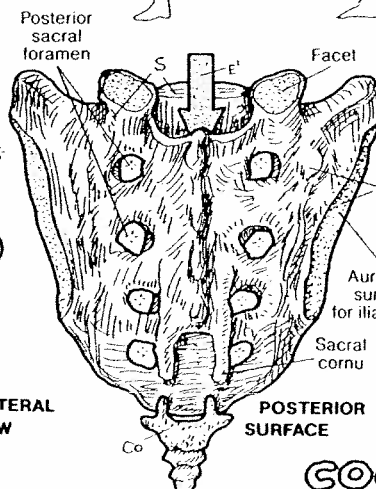
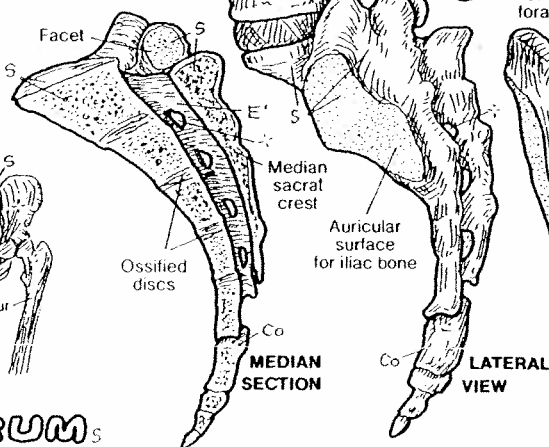
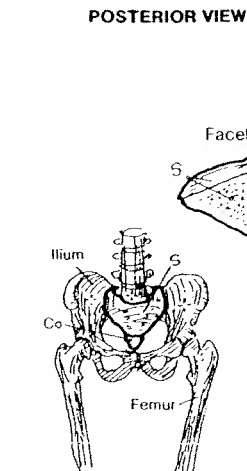
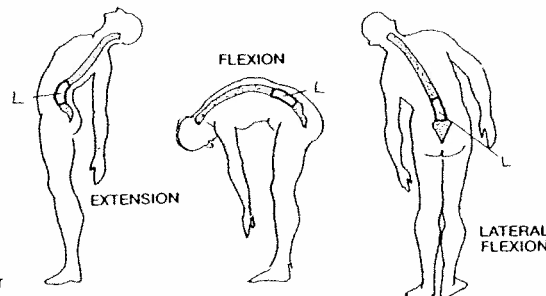
The five lumbar vertebrae are the most massive of all the individual vertebrae, their thick processes securing the attachments of numerous ligaments and muscles/tendons. Significant flexion and extension of the lumbar and lumbosacral motion segments, particularly at L4-L5 and L5-S1, are possible. At about L1, the spinal cord terminates and the cauda equina (bundle of lumbar, sacral, and coccygeal nerve roots; see Plate 21) begins. The lumbar intervertebral foramina are large. Transiting nerve roots/sheaths take up only about 50% of the volume of these foramina. Disc and facet degeneration is common in the L4-5 and L5-S1 segments; reduction of space for the nerve roots increases the risk of nerve root irritation/compression (radiculitis/radiculopathy). Occasionally, the L5 vertebra is partially or completely fused to the sacrum (sacralized L5). The S1 vertebra may be partially or wholly non-fused (lumbarized S1), resulting in essentially six lumbar vertebrae.



PLANES OF ARTICULAR FACETS: CERVICAL_T THORACIC_T LUMBAR_L



The planes (orientation) of the articular facets determine the direction and influence the degree of motion segment movement. The plane of the cervical facets is angled coronally off the horizontal plane about 30°. Considerable freedom of movement of the cervical spine is permitted in all planes (sagittal, coronal, horizontal). The thoracic facets lie more vertically in the coronal plane, and are virtually non-weightbearing. The range of motion here is significantly limited in all planes, less so in rotation. The plane of the lumbar facets is largely sagittal, resisting rotation of the lumbar spine, transitioning to a more coronal orientation at L5-S1. The L4-L5 facet joints permit the greatest degree of lumbar motion in all planes.



SACRUM_S

The sacrum consists of five fused vertebrae; the intervertebral discs are completely replaced by bone. The sacral (vertebral) canal contains the caudal sac of the dura mater (dural sac, thecal sac) to S2 and the sacral nerve roots, which transit the sacral foramina. The sacrum joins with the ilium of the hip bone at the auricular surface, forming the sacroiliac joint.

The sacrum and the ilia of the hip bones form an arch for the transmission and distribution of weightbearing forces to the heads of the femora. It is a strong arch, and the sacrum is its keystone. The coccyx consists of 2-4 tiny individual or partly fused, rudimentary vertebrae. The first coccygeal vertebra is the most completely developed.